## Comment on "Low Fractal Dimension Cluster-Dilute Soot Aggregates from a Premixed Flame"

Chakrabarty *et al.* [1] report small subsets (3%) of soot particles with unusually low average fractal dimensions between 1.2 and 1.51 which is in contradiction with previous reported fractal dimensions. We believe that this is due to a misinterpretation of their measurements, because the technique they use correlates particle size and fractal dimension. The fractal dimension determined for their subset is not equal to the average fractal dimension of the individual particles.

To support our claim we have used a detailed stochastic particle model [2] to simulate soot particles in the flame described by Chakrabarty *et al.* [1]. This model has been previously validated over a number of different flame conditions. We have been able to select a subset of the simulated particles with individual fractal dimensions between 1.45 and 2.0 where the fractal dimension of the subset calculated by the method proposed in [1] was 1.22.

We have used two different definitions of the fractal dimension $D_f$:

$$N \sim \left(\frac{R_g}{d_p}\right)^{D_f} \tag{1}$$

and

$$N \sim (\sqrt{LW})^{D_f}, \tag{2}$$

where $R_g$ is the radius of gyration, $d_p$ the average primary particle diameter, $L$ the length, and $W$ the width of the particle. Equation (2) has been used by Chakrabarty *et al.* [1] and is often used by experimentalists because the radius of gyration is hard to obtain. In Fig. 1 we display the soot particles from the simulation. The dots show $\sqrt{LW}$ against the number of primary particles $N$. A least squares fit of Eq. (2) to all the particles reveals a fractal dimension of the ensemble of 1.82. A fractal dimension of 1.78 has been determined fitting Eq. (1).

However, it is possible to select a subset of the particle ensemble that has a fractal dimension of 1.22 according to Eq. (2) used in [1] despite the fact that the average fractal dimension of the individual particles is 1.73. The 160 particles closest to the line with a slope of 1.22 represent this subset. The individual fractal dimension of these particles calculated with Eq. (1) is shown by the crosses. The reason for the apparent low fractal dimension is a dependency of the fractal dimension on the size of the particles. The larger the particles the narrower the distribution and the lower the fractal dimension of the individual particles. In summary, the particles in the subset with a fractal dimension of 1.22 change their fractal dimension from about 1.8 for the small particles to about 1.6 for the large particles. The fractal dimension determined by fitting Eq. (2) does not reflect the average fractal dimension of the individual particles. This fitting technique is only valid if the fractal dimension is independent of the size of the particles.

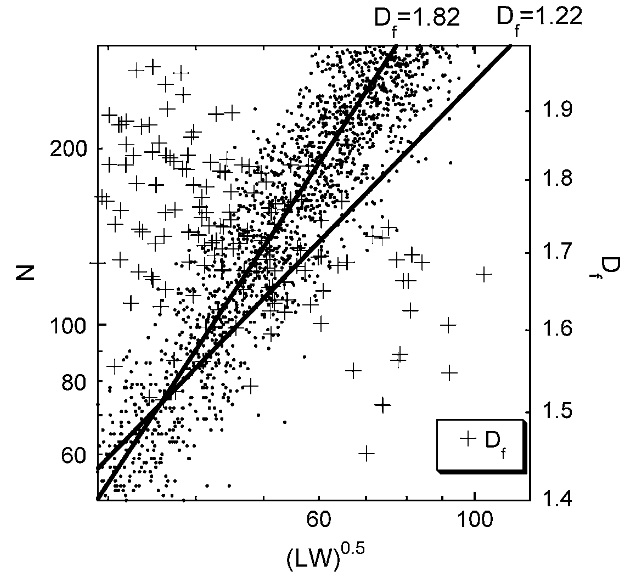


FIG. 1. Fractal dimension of the simulated particles.

We believe that the technique used in [1] selects such a subset of the particles where the fractal dimension is not independent of the size, because the sampling technique is based on the assumption that elongated particles with a low fractal dimension are more likely to be double charged and therefore more likely to be selected. For smaller particles the distance between the charges is not going to vary much even for particles with different fractal dimensions. It is therefore more likely that the resolution of the double charge method with respect to fractal dimension is higher for larger particles where the distance between two charges can be much larger for varying fractal dimensions.

For this reason we believe that the very low fractal dimensions observed by Chakrabarty *et al.* [1] is caused by sampling and process effects.

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[1] R. K. Chakrabarty *et al.*, Phys. Rev. Lett. **102**, 235504 (2009).
[2] M. S. Celnik, M. Sander, A. Raj, R. H. West, and M. Kraft, *Proceedings Combust. Inst.* Vol. 32, p. 639 (2009).

 